MassCleanDiesel: Clean Markets Program: Round III

Massachusetts Department of Environmental Protection

Technology Guide

The Massachusetts Department of Environmental Protection (MassDEP) is accepting grant applications under Round III of the *MassCleanDiesel: Clean Markets Program* to fund technologies to reduce air pollution from diesel transportation refrigeration units (TRUs) that service wholesale markets, warehouses, and distribution centers in Massachusetts. Grants are provided for the purchase and installation of electric TRUs (eTRUs).

- **Electric Transportation Refrigeration Units (eTRUs)**, electricity-powered TRUs that are attached to semi-stationary or stationary trailers to provide heating and cooling.

eTRUs have significant health, environmental, and social benefits. eTRUs also have measurable economic benefits. This guide discusses the benefits of eTRUs as well as their operational characteristics and maintenance requirements. Specific vendors and the products they offer are listed in Section VI at the end of the document.

Technology Benefits

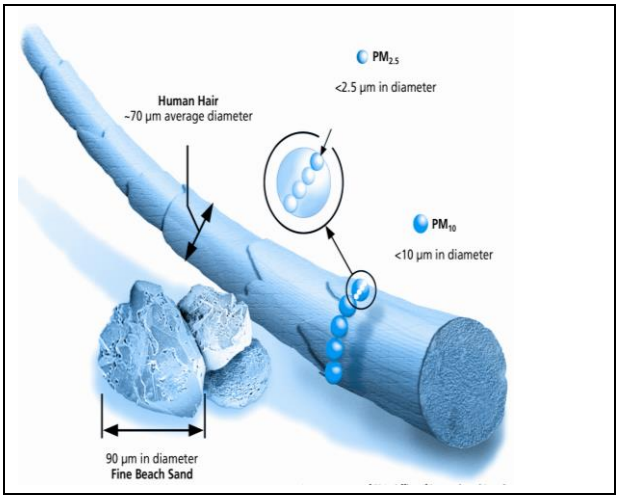
Grant participants can reap a variety of gains with the installation of an eTRU offered through the *MassCleanDiesel: Clean Markets Program.*

Health

Exposure to diesel exhaust can have serious, detrimental effects on human health. Diesel engines emit fine particulate matter (PM) 2.5 micrometers or less in diameter, which is composed of carbon soot and droplets of unburned fuel and lubricating oil. As the diagram on the next page shows, this minute size–a typical human hair is over 25 times wider than a $PM_{2.5}$ particle—allows the particles to slip past the body's defenses and lodge deep within the lungs when inhaled. The smallest particles may even enter the bloodstream directly through the lungs.

Short-term exposure to elevated PM levels can aggravate existing lung disease, increase the severity of asthma attacks, coughing, and acute bronchitis, and intensify susceptibility to heart attacks and arrhythmias in people with existing heart disease.

Diesel Particulate Matter (PM) Size Compared to Human Hair and Beach Sand



Source: US EPA Office of Research & Development

Diesel engines also emit these gaseous pollutants:

- Carbon monoxide (CO), a colorless, poisonous gas that causes headaches, dizziness, and other flu-like symptoms, at low levels of exposure. Because CO can inhibit oxygen intake, exposure at moderate concentrations, may result in angina (chest pain), impaired vision, and reduced brain function.[1]

- Hydrocarbons (HC), exposure to which is associated with chest tightness and shortness of breath. HC contains many toxic compounds, such as benzene and formaldehyde, each of which is designated as a hazardous air pollutant and/or carcinogen and has several wide-ranging health effects. HC and NOx (see below) also react with sunlight and heat to form ground-level ozone, the main component in smog. Short-term exposure to ozone can result in wheezing, throat irritation and coughing.

- Nitrogen oxide (NOx), a gas that at low levels of exposure can cause nausea, irritated eyes and shortness of breath. At high levels of exposure, NOx can lead to swelling of the throat and reduced oxygen intake.

eTRUs, which completely eliminate the use of diesel fuel, also reduce carbon dioxide (CO_2), a greenhouse gas which has been associated with climate change.

eTRUs reduce diesel emissions for people working or living in close proximity to warehousing operations using stationary trailers with diesel transportation refrigerator units. With reduced emissions, workers and residents may experience fewer diesel-related sickness and hospitalizations. eTRUs are also significantly quieter than larger diesel engines and produce fewer exhaust odors, both of which contribute to a healthier working environment.

Environmental

Diesel particles are a major cause of poor visibility in many parts of the United States. Particles in the air scatter and absorb light, reducing the color and clarity of distant objects and views. In addition, diesel particles settling on water alter the nutrient balance of coastal waters, lakes and streams while diesel particles settling on land damage sensitive forests and farm crops and deplete soil nutrients. In both events the particles negatively affect the diversity of ecosystems.

eTRUs offered in the *MassCleanDiesel: Clean Markets Program* reduce diesel particles as well as other pollution that adversely affect the environment, as shown in Table 3:

Table 3. Pollutant Reduction by eTRUs (At Source)

Device	Pollutants (% Reduction)			
	PM	NOx	HC	CO
eTRU	100%	100%	100%	100%

[1] http://www.epa.gov/iaq/co.html

Economic

Participants who opt for eTRUs on their trailers will save significant amounts of money in fuel and maintenance costs.

Electric TRUs installed on trailers used for cold storage provide direct economic benefit by eliminating diesel fuel consumption and shifting the refrigeration power source from a diesel engine to the more economical and efficient electrical power grid. eTRU owners can expect:

- ✓ *Lower Maintenance Costs.* Electric motors have fewer moving parts and therefore require minimal maintenance compared to diesel engines.
- ✓ *Greater Reliability*. New electric motors are designed for years of trouble-free operation.
- ✓ *Lower Energy Costs.* Monthly electricity costs are about 80% of current monthly diesel fuel costs.
- ✓ *Reduced Administrative Burden.* Switching to electrically powered units eliminates the need for fuel delivery scheduling and payments.

This program will fund 40% of the cost to replace a diesel-powered TRU with a new electric unit, with 60% of the total cost borne by the equipment owner. Based on the average cost of the eTRUs supplied in Round I of the Clean Markets Program, grant recipients in Round III can expect to pay approximately $10,800 (plus state taxes on the $10,800) as their share of the total eTRU cost.

After taking this co-pay into account, the fuel savings from switching from a diesel-fueled TRU to an electricity-powered TRU are projected to cost grant applicants between $7,086 to $8,968 in the first year of the program. Thereafter, annual fuel savings are expected to range from $1,832 to $3,714 a year after accounting for annual electricity costs. *Lifetime savings, based on a 12-year lifespan of an eTRU and the factors cited above, could range from $11,184 to $33,768 for just one eTRU* at current energy prices.

Table 2. Example of eTRU Annual and Lifetime Savings

Annual Number of Hours Diesel TRU Used	Annual Number of Gallons Used/ Diesel TRU[4]	Annual Diesel Fuel Cost[5]	Annual Electric Costs/ eTRU[6]	Total Saved/Yr (Electric Included)	Average 60% Co-Pay for eTRU[7]	First Year Total Cost (Electric & Co-Pay Included)	Lifetime Total Saved (Electric & Co-Pay Included)[8]
4,320[1]	3,456	$ 9,608	$ 7,776	$ 1,832	$ 10,800	$ 8,968	$ 11,184
6,480[2]	5,184	$ 14,412	$ 11,664	$ 2,748	$ 10,800	$ 8,052	$ 22,176
8,760[3]	7,008	$ 19,482	$ 15,768	$ 3,714	$ 10,800	$ 7,086	$ 33,768

Numbers are based on: [1] 24-hr/day continuous operation for 6 months; [2] 24-hr/day operation for 9 mos.; [3] Year-round 24-hr/day operation; [4] Diesel TRU fuel consumption of 0.8 gallons/hr; [5] Diesel fuel cost of $2.78/gallon; [6] Cost to operate an average 15 kW eTRU (about 56,000 BTUs) at $0.12/kWhr; [7] Average co-pay of grantees based on 60% copay; [8] Average eTRU lifespan of 12 yrs. after considering first-year costs.

These savings will vary of course with the number of hours the diesel unit operated, the cost of the electricity, and how much the new electric unit operates. Some Round I grant recipients found that they used the new electric unit more than their old diesel unit because the electric unit polluted less, ran more efficiently, and required less maintenance.

The savings do not reflect the price to install or upgrade the facility's electric service; if new electrical service is required, the estimated costs range from $1,000 to $5,000 per trailer bay. The lifetime savings potential of the eTRU technology, however, will soon make up for any electricity infrastructure costs that an owner might incur.

The diesel emission reduction technologies offered in this grant may produce indirect, long-term economic gains. Employees who are no longer exposed to significant amounts of exhaust pollution may be sick less often, experience improved productivity, and require less investment in health care costs.

Social

Businesses that proactively install these technologies demonstrate that they care about their employees and neighbors. Participation in this program could be seen as an act of social responsibility that may return intangible dividends in the future, such as community recognition and improved quality of life for your employees and the community at large.

I. Electric Transportation Refrigeration Units (eTRUs)

Operational Characteristics

Electric TRU and Power Supply

Source: M.J. Bradley & Associates, LLC

A transportation refrigeration unit (TRU) is a compact refrigeration system that is installed on a mobile or stationary trailer to cool the trailer's interior for storage and/or transport of perishable goods (the Clean Markets Program is only providing eTRUs for stationary and semi-stationary trailers). Most TRUs are powered by small diesel engines that constantly run to keep temperatures in the trailer at the desired set-point. Over the course of a year, a diesel TRU that runs continuously may consume as much as 7,000 gallons of diesel fuel and emit a significant amount of diesel pollutants. An electric TRU is plugged into a facility's on-site electrical infrastructure, thereby eliminating the use of diesel fuel.

Emission Reductions

eTRUs have zero emissions, thereby reducing PM, NOx, HC, and CO by 100%. Eliminating these pollutants at the source provides a better working environment for workers and local residents. The power plant generating the electricity for the eTRU still emits these pollutants but at a much lower rate than a diesel unit.

Installation

An eTRU is designed to be the same size as the existing diesel TRU. Installation is straightforward and requires very little or no modification to the trailer. The diesel unit is removed and the new electric unit is installed. Participating TRU owners are responsible for arranging appropriate electrical power infrastructure, including completing any needed upgrades to their facility's existing electrical system. (Electricity supply installation or upgrade costs are not funded by this grant program.) Each eTRU will require a 480 VAC/3-phase/30 amp or a 240 VAC/3-phase/60 amp outlet. Factors influencing infrastructure costs include:

- The number of eTRUs to be installed (each eTRU consumes ~12 kWh);
- The availability of excess electrical capacity at the facility;
- The method of providing electrical service to the eTRU (running power supply cord over the trailer to the eTRU vs. installing permanent power supply at the eTRU end of the trailer with buried conduit); and,
- The location of the electrical service relative to the eTRU (i.e., distance necessary to install electrical service).

Maintenance

The electric motors of eTRUs are designed for years of trouble-free operation. The eTRU system requires very little maintenance, with only a one-hour inspection service annually. Recommended parts to inspect include the valve pressure, refrigerant charge, moisture level, voltage, amp readings and pressure wash coils.

Costs

The *estimated* cost provided by pre-qualified vendors in this program to purchase and install an eTRU ranges from $13,902 to $24,159, depending on the vendor and specifics of the technology.

MassDEP will fund a maximum of 40% of the cost to purchase and install an eTRU. The eTRU owner would be responsible for funding the remaining 60% of the cost plus the installation of a new or upgraded existing electrical supply. Electrical infrastructure improvements are estimated to cost between $1,000 - $5,000 per bay, depending on existing electrical service and the extent to which new circuits need to be wired.

II. eTRU Manufacturers and Vendor Suppliers

These tables list the vendors that are providing the technologies offered in this grant program. ***Prices are estimated and may vary due to additional parts, labor, or travel charges****. Prices are also subject to change at the time of contract negotiations with vendors.*

eTRUs (40% Funded)

Vendor	Manufacturer	Product	Single/Multi-Temperature	Estimated Total Cost
Thermo King NE	Zanotti	EFZ520	Both	$24,159
Thermo King NE	Zanotti	MAS340	Both	$13,902
Thermo King NE	Zanotti	BAS340	Both	$15,582
Thermo King NE	Zanotti	PAS340	Both	$20,321
Thermo King NE	Thermo King	SBE-30	Both	$15,453